531 Rec'd PCT/... 26 DEC 2001

FORM PTO-1390 (REV 11-2000)	U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 36-1513
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 C.F.R. 1 5) 10/019080 Unknown
INTERNATIONAL APPLICATION NO. **PCT/GB00/02780**	INTERNATIONAL FILING DATE **19 July 2000**	PRIORITY DATE CLAIMED **23 July 1999**

TITLE OF INVENTION

OPTICAL REGENERATOR

APPLICANT(S) FOR DO/EO/US

COTTER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The U.S. has been elected by the expiration of 19 months from the priority date (Article 31).
5. A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   - b. ☒ has been communicated by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☐ is attached hereto.
   - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ have been communicated by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has **NOT** expired.
   - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 To 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information. AMENDED SHEETS, pages 2, 3, 4, 4a, 8 and 9

531 Rec'd PCT/PTO 26 DEC 2001

U.S. APPLICATION NO (If known, see 37 C.F.R. 1.5) 10/019080 Unknown	INTERNATIONAL APPLICATION NO PCT/GB00/02780	ATTORNEY'S DOCKET NUMBER 36-1513

21. ☒ The following fees are submitted:

	CALCULATIONS		PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): -- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .... $1040.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO .... $890.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO .... $740.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) .... $710.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00			
ENTER APPROPRIATE BASIC FEE AMOUNT =	$	890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).	$	0.00	

CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE				
Total Claims	8	-20 =	0	X	$18.00	$	0.00	
Independent Claims	2	-3 =	0	X	$84.00		0.00	
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)				$280.00		$	0.00	
					TOTAL OF ABOVE CALCULATIONS =	$	**890.00**	

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.		0.00	
SUBTOTAL =	$	**890.00**	
Processing fee of $130.00, for furnishing the English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)). +		0.00	
TOTAL NATIONAL FEE =	$	**890.00**	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). **$40.00** per property +	$	40.00	
Fee for Petition to Revive Unintentionally Abandoned Application ($1280.00 – Small Entity = $640.00)	$	0.00	
TOTAL FEES ENCLOSED =	$	**930.00**	
	Amount to be: refunded	$	
	Charged	$	

a. ☒ A check in the amount of $930.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 14-1140 in the amount of $_____ to cover the above fees. A duplicate copy of this form is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-1140. A duplicate copy of this form is enclosed.

d. ☒ The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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25,640 — REGISTRATION NUMBER
December 26, 2001 — Date

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

COTTER Atty. Ref.: **36-1513**

Serial No. **Unknown** Group:

National Phase of: **PCT/GB00/02780**
International Filing Date: **19 July 2000**

Filed: **December 26, 2001** Examiner:

For: **OPTICAL REGENERATOR**

* * * * * * * * * * *

December 26, 2001

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

PRELIMINARY AMENDMENT

Prior to calculation of the filing fee and in order to place the above identified application in better condition for examination, please amend as follows:

IN THE SPECIFICATION

Page 1, after the title insert the following:

-- This application is the US national phase of international application PCT/GB00/02780 filed July 19, 2000 which designated the U.S. --.

IN THE CLAIMS (AS ON AMENDED SHEETS)

Please substitute the following amended claims for corresponding claims previously presented. A copy of the amended claims showing current revisions is attached.

3. (Amended) A regenerator according to claim 1, in which the regenerator is arranged to regenerate a received bit-asynchronous optical packet, and in which each of the gate means (9, 10) of the regeneration stage includes an array of optical gates (31-34), means for imposing different respective delays between the clock signal and

the data signal at each of the gates making up the array and switch means for selecting an optical output from one of the gates in the array depending on the bit-level phase of the received optical packet.

6. (Amended) A method according to claim 4, in which the step of gating the clock signal includes applying each of the said data streams to an array of optical gates (31-34), imposing different respective delays between the clock signal and the data signal at each of the gates making up an array, and selecting an optical output from one of the plurality of gates in each array depending on the bit level phase of a received bit-asynchronous optical data signal.

7. (Amended) A node for connection in an optical network and including a regenerator according to claim 1.

8. (Amended) An optical network including a regenerator according to claim 1.

REMARKS

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version with markings to show changes made**."

The above amendments are made to place the claims in a more traditional format.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

3. (Amended) A regenerator according to [claims 1 or 2] claim 1, in which the regenerator is arranged to regenerate a received bit-asynchronous optical packet, and in which each of the gate means (9, 10) of the regeneration stage includes an array of optical gates (31-34), means for imposing different respective delays between the clock signal and the data signal at each of the gates making up the array and switch means for selecting an optical output from one of the gates in the array depending on the bit-level phase of the received optical packet.

6. (Amended) A method according to claim 4 [or 5], in which the step of gating the clock signal includes applying each of the said data streams to an array of optical gates (31-34), imposing different respective delays between the clock signal and the data signal at each of the gates making up an array, and selecting an optical output from one of the plurality of gates in each array depending on the bit level phase of a received bit-asynchronous optical data signal.

7. (Amended) A node for connection in an optical network and including a regenerator according to [any one of claims 1 to 3] claim 1.

8. (Amended) An optical network including a regenerator according to [any one of claims 1 to 3] claim 1.

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531 Rec'd PCT/PTO 28 DEC 2001

OPTICAL REGENERATOR

The present invention relates to an optical regenerator suitable for use with optical time division multiplexed (OTDM) signals carried on an optical network. The signals may be, for example, optical packets or a circuit switched data stream.

In order to use fully the bandwidth available on optical communications networks, it is desirable to transmit time division multiplexed signals at a very high bit rate of tens or hundreds of Gbits per second. However, the very short duration pulses making up such signals soon suffer degradation in shape, timing and signal-to-noise ratio resulting, for example, from noise in optical amplifiers, dispersion in the optical transmission medium and/or from the effects of processing at nodes traversed by the packet. Therefore, if the extent of the optical network is not to be undesirably limited, it is necessary to use an optical regenerator to restore the timing and shape of the pulse train making up the optical signals. Ideally, the regenerator will function as a "3R" regenerator, that is it will re-amplify, re-time and re-shape the pulses. Examples of suitable optical regenerators are described in Lucek J and Smith K, Optics Letters, 18, 1226-28 (1993), and in Phillips I D, Ellis A D, Thiele H J, Manning R J and Kelly A E, Electronics Letters, 34, 2340-2342 (1998). The use of such techniques makes it possible to maintain the integrity of the optical data signals as they pass through a very large number of nodes. For example, Thiele H J, Ellis A D and Phillips I D, Electronics Letters, 35, 230-231 (1999) describe cascaded 40 Gbit/s 3R data regeneration in a recirculating loop. With a regenerator spacing of 100 km, the error-free transmission distance in the loop is extended by an order of magnitude, from 200 km to greater than 2000 km. Regenerators made from semiconductor non-linear optical devices, rather than fibre non-linear optical devices, are preferred because they are compact, stable, easily integrated, and operate at relatively low pulse energy.

Typically, an optical regenerator comprises an optical gate having a first optical input that receives an optical clock signal at the data line rate, and a second optical input, the control input that receives the data signal that is to be regenerated. Typically the gate, which includes a non-linear optical element, changes to a transmissive state when a binary digit '1' occurs in the optical control signal that is applied, and reverts to the original non-transmissive state after a certain fixed time

known as the gate window. The state of the gate is unchanged if a binary digit '0' occurs in the optical control signal. The state of the non-linear element then determines whether a given pulse in the optical clock train at the input to the gate is passed on to the output from the gate. In this way, the bit pattern in the input data stream is imposed on the optical clock train and output to form a regenerated optical data stream. However, while experiments reported in Kelly A E et al, Electronics Letters, (in press, July 1999) have shown that semiconductor-based all-optical regenerators can function at bit rates as high as 80Gbit/s it has been found that they are unable to perform satisfactorily at still higher bit rates, since then in general the bit period is very much less than the recovery time of the optical gate, so that the regenerated signals contain patterning effects which lead to bit errors.

According to a first aspect of the present invention, there is provided an optical regenerator including: (a) a data division stage arranged to receive an incoming optical data stream having a bit rate and to divide the incoming optical data stream into a plurality of further optical data streams each having a lower bit rate than the bit rate of the incoming data stream; and, (b) a regeneration stage, including a plurality of optical gate means each arranged to receive a respective one of the further data streams at its control input and to receive at another input an optical clock stream at the frequency of the bit rate of the further data streams or a multiple thereof, wherein the outputs of the gate means are connected in common to an optical output (5) of the regenerator and arranged to provide a bit interleaved regenerated optical data stream at the said output.

The present invention provides an all-optical generator that is able to function at far higher bit rates than existing designs. For example, using current technologies, an all-optical regenerator functioning at 160Gbit/s can be constructed. The present inventors have realised that although the functioning of an optical regenerator is limited by the recovery time of the optical gate, the impact of that recovery time is different for a regular clock signal, as opposed to a signal comprising a random data sequence. Accordingly, a gate that may be able to function effectively as a regenerator for data signals only up to 80Gbit/s can nonetheless function as a demultiplexer for data signals at twice that bit rate. The regenerator of the present invention takes advantage of this difference to provide a system capable of operating at far higher bit rates. This is achieved by first dividing down the higher bit rate data

ART 34 AMDT

stream into a number of parallel data streams at a lower bit rate and then applying these different divided data streams at the lower bit rate as control signals to a number of gates, each of which is receiving a clock signal at the frequency of the lower bit rate or a multiple thereof at its input. Then when the outputs of the different gates are interleaved, the result is a regenerated data stream at the higher bit rate.

Preferably the data division stage comprises a plurality of gate means each arranged to receive the data stream at a respective driving input and a clock stream at the frequency of the lower bit rate at a respective control input and delay means arranged to impose a different respective delay on the clock signal at the frequency of the lower bit rate relative to the higher bit rate data signal for each of the respective gate means.

The all-optical regenerator may be arranged to function in a bit synchronous network, in which case it may receive clock signals from local clock sources that are synchronised to a bit-level clock. In such a system, each of the gate means may comprise a single optical gate, for example using a TOAD (teraHertz optical asymmetrical demultiplexer) structure.

Alternatively, the optical regenerator may be used in a network which functions asynchronously at the bit-level. In this case, the optical regenerator may incorporate the regenerator structures described and claimed in the present applicant's co-pending application PCT/GB99/01159. In this case, each of the gate means in the regeneration stage may comprise an array of optical gates, and delay means arranged to impose a different respective delay in the clock stream relative to the data stream at each of the array of optical gates, and an optical switch connected to the outputs of all of the array of optical gates, and arranged selectively to output the optical data stream from one of the gates of the array. Alternatively, as described in our co-pending application, a single gate means may be used in conjunction with means to shift the phase of the incoming packet to match that of a local free-running optical clock source.

According to a second aspect of the present invention, there is provided a. A method of regenerating an optical data signal including:

(a) dividing an incoming optical data signal at a bit rate into a plurality of further data streams each having a lower bit rate than the bit rate of the received optical signal;

(b) gating under the control of the plurality of further data streams a clock signal at the frequency of the bit rate of the further signals or a multiple thereof; and

interleaving the optical signals produced by step (b) thereby creating a re-generated optical signal at the bit rate of the received optical data signal.

Systems embodying the present invention will now be described in further detail by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic of an optical regenerator embodying the invention;

Figure 2 is a diagram showing an optical gate suitable for use in the regenerator in Figure 1;

Figure 3 is a diagram showing a gate array for use in the regenerating stage of an asynchronous optical regenerator embodying the invention.

An optical regenerator comprises an optical data division stage 1 and an optical regeneration stage 2. An optical time division multiplexed (OTDM) data stream at a high bit rate, in this example 160Gbit/s, is received at an optical input 3 of the data division stage 1. Divided data streams at a lower bit rate, in this example 80Gbit/s are passed from optical outputs 4a, 4b of the data division stage 1 into the optical regeneration stage 2. The data streams are used to gate an optical clock signal at the frequency of the lower bit rate or a multiple thereof, in this example 80 GHz, so as to produce at the optical output 5 of the regeneration stage 2 a regenerated high bit-rate optical data stream.

In a regenerator for use with a synchronous data stream, the data division and regeneration stages require in total 2n optical gates where n is the ratio between the bit rate of the optical data stream and the lower bit rate of the divided data streams input to the regeneration stage 2. In the present example, n = 2 and there are two optical gates in the division stage 1 and a further two optical gates in the regeneration stage 2. As shown in Figure 1, each of the two gates in the division stage 1 is connected in common to the optical input 3 and is driven by the 160Gbit/s optical pulse stream. An optical clock signal at the lower bit rate of 80GHz is applied

ART 34 AMDT

4a

to each of the optical gates 6, 7. An optical delay 8 is included between the optical feeds to the gates 6, 7. The magnitude of the optical delay is said to be equal to the

separation between successive bits in the optical data stream at the input 3. As a result, the two optical gates 6, 7 each pass every other bit of the input data stream with, for example, gate 6 passing the optical pulses in bit positions 0, 2, 4 ... and the other gate 7 passing the optical pulses in bit positions 1, 3, 5... The resulting divided data streams at the lower bit rate are passed to the optical outputs 4a, 4b of the data division stage 1. In the regeneration stage 2, a further pair of optical gates 9, 10 are driven by the 80GHz optical clock signal. A respective one of the divided data signals is applied as a control signal to each of the gates 9, 10. An optical delay 11 is included in the output from one of the gates 9, 10 and is arranged to impose a relative delay between the outputs of the gates 9, 10 that is complementary to the delay imposed in the data division stage 1. The outputs of the gates 9, 10 are then combined by an optical coupler 12. In this way, the two lower bit rate data streams are modulated onto the higher bit rate clock and interleaved to produce an output signal at 160Gbit/s that is regenerated in shape, amplitude and timing, that is it has undergone 3R regeneration.

Figure 2 shows one possible construction for an optical gate for use in the circuit of Figure 1. In this case, the gate uses a TOAD configuration. A fibre loop mirror 21 includes a non-linear element 22 which may be, for example, an optical semiconductor amplifier. The non-linear element 22 is offset with respect to the centre of the loop mirror. The duration of the switching window is determined by the extent of the offset. A gating control signal is applied to the loop via an optical coupler 23.

Fibre loop mirrors in which the fibre itself acts as the non-linear element are described, for example, in Whittaker et al, Optical Letters, vol. 16, page 1840 (1991). The use of non-linearities in semiconductor optical amplifiers as an ultrafast gating device is described, for example, by Kang et al in the International Journal of High Speed Electronics and Systems, vol. 7, page 125 (1996). As an alternative to the use of a semiconductor optical amplifier in a loop configuration as shown in Figure 2, an optical gate may use a pair of amplifiers in a Mach-Zehnder interferometer configuration. Another ultrafast optical gate is the ultrafast non-linear interferometer switch described by Hall and Rauschenbach (Paper BD5, Proceedings of Conference on Optical Fibre Communications (OFC '98) Optical Society of America, February 1998). It is characteristic of all these devices, that they suffer

significant speed limitations as a result of the recovery time of the non-linear element when the gate is driven by an irregular data signal. However, they can function at considerably higher data rates when driven by a regular clock signal.

To generate the clock signals at and the frequency of the lower bit rate, a clock recovery circuit may be used to derive a clock signal in synchronism with the incoming data bits and this clock signal may be used to synchronise a local pulse source running at 80GHz. For example, the clock recovery circuit may comprise a passive pulse replication network that replicates a marker pulse to produce a regular pulse pattern.

In an alternative embodiment, the optical regenerator is arranged to handle incoming optical packets that are asynchronous at the bit-level. In this case, each of the single optical gates 9, 10 in the regenerative stage of Figure 1 is replaced by an array of gates. One such array is shown in Figure 3. The array comprises four optical gates 31, 32, 33, 34. Each of the gates is driven by the 160Gbit/s data stream. Different relative delays of a fraction of a bit period are included in the input paths for the driving signals. This delay has a value of 0 for the input to the first optical gate 31 $\pi/4$ for the second optical gate 32, $\pi/2$ for the third optical gate 33, and $3\pi/4$ for the final optical gate 34. The outputs from the four optical gates are passed to a 4:1 optical switch which selects the data stream from one of the gates to be passed to the respective optical output 4a, 4b. The appropriately synchronised output may be selected, for example, by tapping off a fraction of the output from the switch C and measuring, for example using a photo detector, the optical energy in the data signal each of the different gates is selected. When the phase error between the clock signal and driving data signal is minimised, then the corresponding gate output will give a peak in the energy function. Electronic control logic may be used to generate an electronic control signal for the 4:1 switch. The lower switching rates of electronic control logic is not a limiting factor, since the selection of an optical output from the gate array only needs to be repeated at the packet rate. In such systems handling bit asynchronous optical packets, the optical clock signals may be derived from free-running optical pulse sources. A suitable source comprises an electronic microwave oscillator driving an electrically synchronised laser, such as a gain-switched laser or an actively mode-locked laser. Alternative, a continuously free-running optical pulse source such as a passively mode-locked laser may be used.

In general, an asynchronous optical regenerator will require 5 n gates, where n is the ratio between the higher bit rate and the lower bit rate.

Figure 4 shows, by way of example, an optical network in which a node includes a bit-asynchronous regenerator embodying the invention. Packets arrive at the node referenced B from a number of sources, each of which have independent, uncorrelated clocks. . By suitable adjustment of the transmitted power at the source, the power levels in any optical amplifiers used in the link, and also the power levels at any synchronous regenerators used in the link, the bits in the packets arriving at the input of a routing node may conveniently have an intensity at an appropriately-defined standard 'digital' level (e.g. of the correct intensity to perform complete switching in the optical gate or gates used in the bit-asynchronous packet regenerator AR in the switching node). The inputs to the switching nodes will, in general, be bit-asynchronous. Each input to a routing node may pass through a bit-asynchronous packet regenerator AR, constructed as described above. As is shown schematically in Figure 4 a node, such as that referenced node B, may combine an add/drop function for local traffic as well as regenerating packets for onward transmission.

ART 34 AMDT

CLAIMS

1. An optical regenerator including:

(a) a data division stage (1) arranged to receive an incoming optical data stream having a bit rate and to divide the incoming optical data stream into a plurality of further optical data streams each having a lower bit rate than the bit rate of the incoming data stream; and

(b) a regeneration stage (2), including a plurality of optical gate means (9,10) each arranged to receive a respective one of the further data streams at its control input and to receive at another input an optical clock stream at the frequency of the bit rate of the further data streams or a multiple thereof, wherein the outputs of the gate means are connected in common to an optical output (5) of the regenerator and arranged to provide a bit-interleaved regenerated optical data stream at the said output (5).

2. A regenerator according to claim 1, in which the data division stage (2) includes a plurality of optical gate means (9,10) each arranged to receive the incoming data stream at a respective data input and to receive at a respective control input an optical clock stream at the frequency of the bit rate of the further signals, and delay means arranged to impose a different respective delay (11) on the said optical clock stream relative to the incoming data signal for each of the respective gate means.

3. A regenerator according to claims 1 or 2, in which the regenerator is arranged to regenerate a received bit-asynchronous optical packet, and in which each of the gate means (9,10) of the regeneration stage includes an array of optical gates (31-34), means for imposing different respective delays between the clock signal and the data signal at each of the gates making up the array and switch means for selecting an optical output from one of the gates in the array depending on the bit-level phase of the received optical packet.

4. A method of regenerating an optical data signal including the steps of:

(a) dividing an incoming optical data signal at a bit rate into a plurality of further data optical streams each having a lower bit rate than the bit rate of the incoming optical signal;

(b) gating under the control of the plurality of further data streams a clock signal at the frequency of the bit rate of the further signals or a multiple thereof; and

(c) interleaving the optical signals produced by step (b) thereby creating a re-generated optical signal at the bit rate of the received optical data signal.

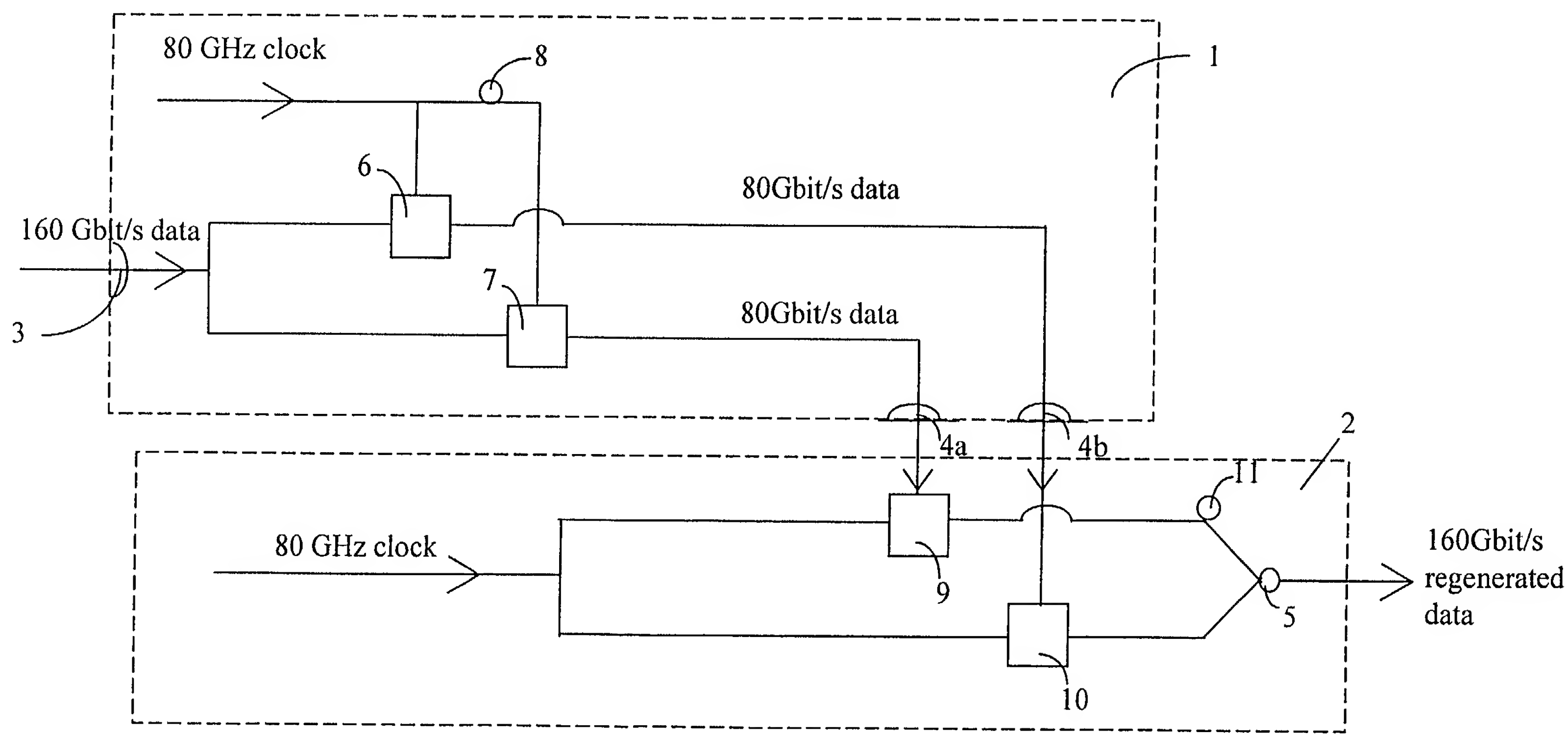
5. A method according to claim 4, in which the step of dividing the optical data signal includes applying the incoming optical data signal to a respective input of each of a plurality of gate means, applying to a respective control input of each of the plurality of gate means an optical clock stream at the frequency of the bit rate of the further signals or a multiple thereof, and imposing a different respective delay relative to the higher bit rate data signal on each of the said optical clock streams.

6. A method according to claim 4 or 5, in which the step of gating the clock signal includes applying each of the said data streams to an array of optical gates (31-34), imposing different respective delays between the clock signal and the data signal at each of the gates making up an array, and selecting an optical output from one of the plurality of gates in each array depending on the bit level phase of a received bit-asynchronous optical data signal.

7. A node for connection in an optical network and including a regenerator according to any one of claims 1 to 3.

8. An optical network including a regenerator according to any one of claims 1 to 3.

Figure 1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8
1
6
80Gbit/s data
160 Gbit/s data
7
3
80Gbit/s data
4a
4b
2
11
80 GHz clock
160Gbit/s
regenerated
data
9
5
10

Figure 2

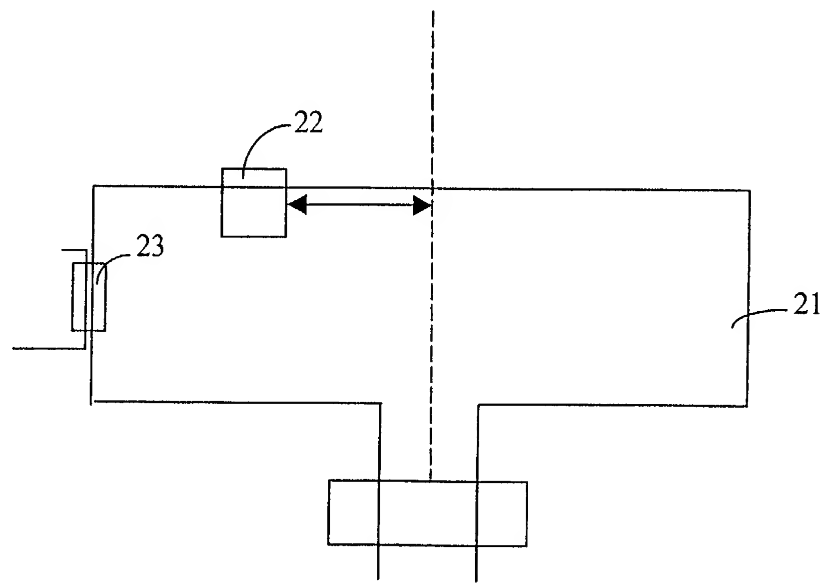


Figure 3

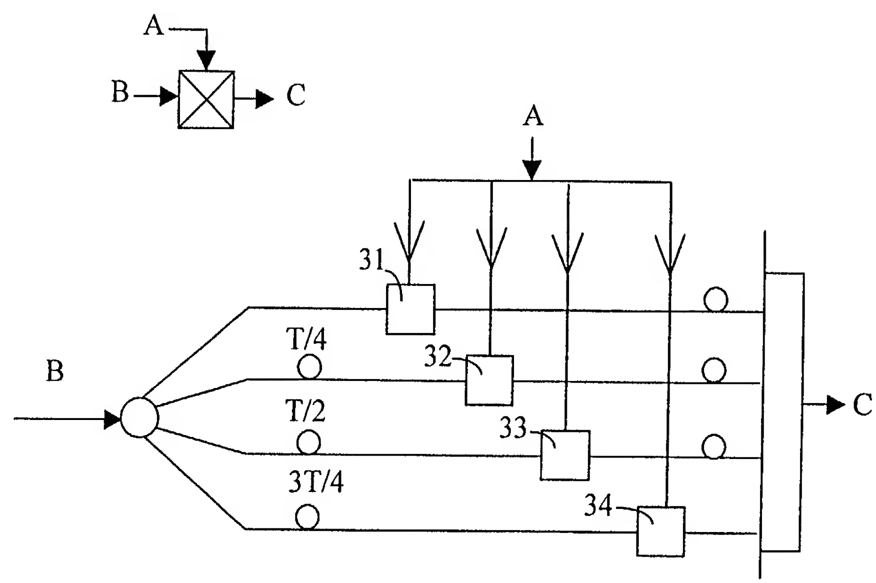
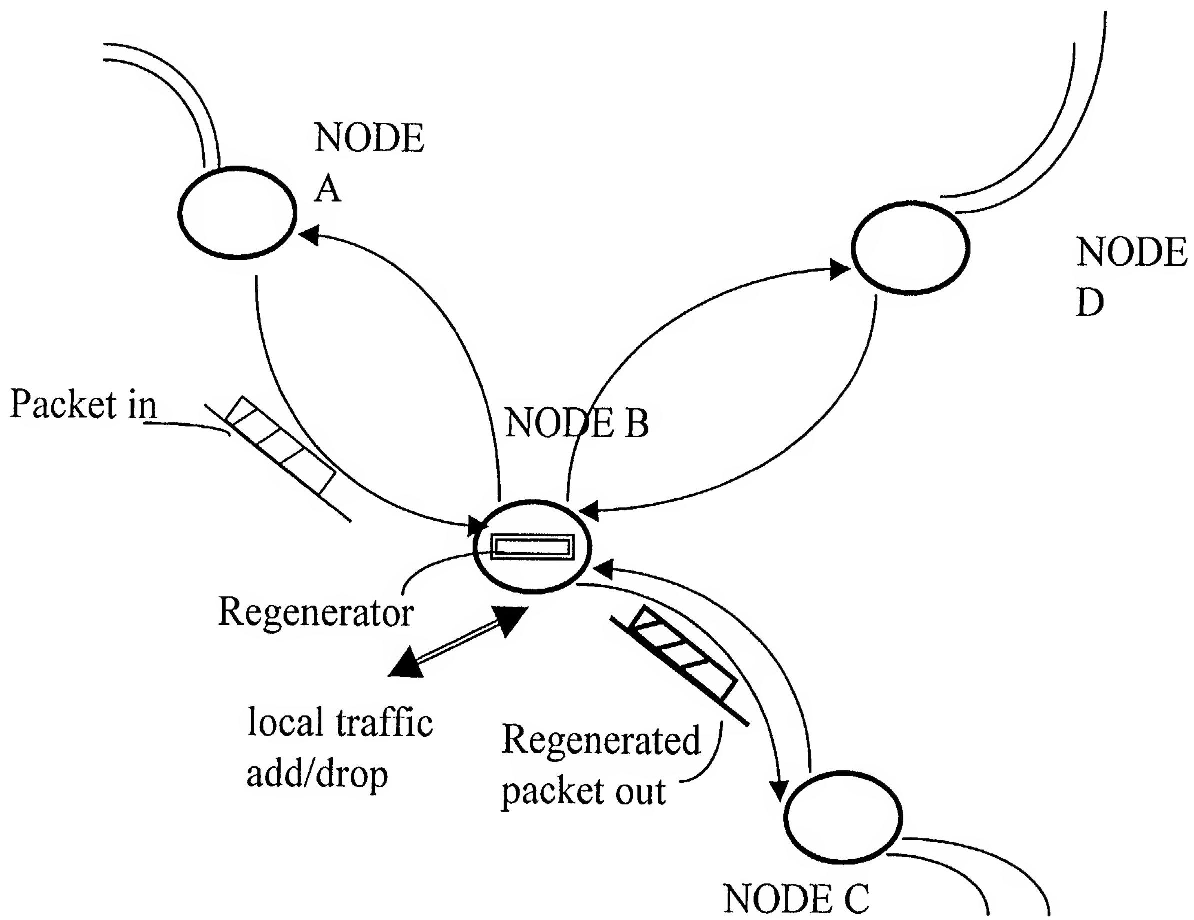


Figure 4


NODE
A
NODE
D
Packet in
NODE B
Regenerator
local traffic
add/drop
Regenerated
packet out
NODE C

A25819 USw

Nixon & Vanderhye P.C. (10/99)
(Domestic Non-Assigned/Foreign)

RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

OPTICAL REGENERATOR

the specification of which (**check** applicable **box(s)**):

☐ is attached hereto
☐ was filed on ______ as U.S. Application Serial No. ______ (Atty Dkt. No. ______-)
☒ was filed as PCT International application No. **PCT/GB** 00/02780 on 19 JULY 2000
and (if applicable to U.S. or PCT application) was amended on ______

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed or, if no priority is claimed, before the filing date of this application:

Priority Foreign Application(s):

Application Number	**Country**	**Day/Month/Year Filed**
99305834.6	EUROPE	23 JULY 1999

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

Application Number	**Date/Month/Year Filed**

I hereby claim the benefit under 35 U.S.C. 120/365 of all prior United States and PCT international applications listed above or below and, insofar as the subject matter of each of the claims of this application is not disclosed in such prior applications in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. 1.56 which occurred between the filing date of the prior applications and the national or PCT international filing date of this application:

Prior U.S./PCT Application(s):

Application Serial No.	**Day/Month/Year Filed**	**Status: patented pending, abandoned**
PCT/GB00/02780	19 JULY 2000	PENDING

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. And on behalf of the owner(s) hereof, I hereby appoint **NIXON & VANDERHYE P.C., 1100 North Glebe Rd., 8th Floor, Arlington, VA 22201-4714, telephone number (703) 816-4000 (to whom all communications are to be directed)**, and the following attorneys thereof (of the same address) individually and collectively owner's/owners' attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent: Arthur R. Crawford, 25327; Larry S. Nixon, 25640; Robert A. Vanderhye, 27076; James T. Hosmer, 30184; Robert W. Faris, 31352; Richard G. Besha, 22770; Mark E. Nusbaum, 32348; Michael J. Keenan, 32106; Bryan H. Davidson, 30251; Stanley C. Spooner, 27393; Leonard C. Mitchard, 29009; Duane M. Byers, 33363; Jeffry H. Nelson, 30481; John R. Lastova, 33149; H. Warren Burnam, Jr. 29366; Thomas E. Byrne, 32205; Mary J. Wilson, 32955; J. Scott Davidson, 33489; Alan M. Kagen, 36178; Robert A. Molan, 29834; B. J. Sadoff, 36663; James D. Berquist, 34776; Updeep S. Gill, 37334; Michael J. Shea, 34725; Donald L. Jackson, 41090; Michelle N. Lester, 32331; Frank P. Presta, 19828; Joseph S. Presta, 35329 I also authorize Nixon & Vanderhye to delete any attorney names/numbers no longer with the firm and to act and rely solely on instructions directly communicated from the person, assignee, attorney, firm, or other organization sending instructions to Nixon & Vanderhye on behalf of the owner(s).

1. Inventor's Signature: David Cotter Date: 31st July 2000
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2. Inventor's Signature: ______ Date: ______
Inventor: (first) MI (last) (citizenship)
Residence: (city) ______ (state/country) ______
Post Office Address: ______
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FOR ADDITIONAL INVENTORS, check box ☐ and attach sheet with same information and signature and date for each.